BELLCOMM, INC.
1100 Seventeenth Street, N.W. Washington, D.C. 20036

SUBJECT: Review of AAP I/C Panel Instrumentation and Communications Interface Control Documents - Case 620

DATE: February 15, 1968

FROM: A. G. Weygand, Jr.

## ABSTRACT

This memorandum contains comments on the drafts of the Interface Control Documents prepared for the Apollo Applications Program (AAP) Instrumentation and Communications (I/C) Panel by Marshall Space Flight Center and distributed to members of the Panel during the sixth meeting of the AAP I/C Panel for review.

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MEMORANDUM FOR FILE

## 1.0 Introduction

This memorandum contains comments on the drafts of the following documents prepared for the Apollo Applications Program (AAP) Instrumentation and Communications (I/C) Panel.

(a) Saturn/AAP Frequency Plan, Instrumentation and Communications Interfaces, 50M13120, draft, dated January 8, 1968.

(b) LM-A/ATM/MSFN Instrumentation and Communications Performance and Interface Specification, 50M13127, draft, dated January 8, 1968.

(c) Multiple Docking Adapter to Airlock Module Instrumentation and Communications Interface, 50M13122, draft, dated January 8, 1968.

(d) Orbital Workshop to Airlock Module Instrumentation and Communications Interface, 50M13121, draft, dated January 1968.

(e) Command Service Module to Multiple Docking Adapter Instrumentation and Communications Interface, 50M13125, draft, dated January 8, 1968.

(f) Apollo Telescope Mount to Lunar Module Instrumentation and Communications Interface, 50M13123, draft, dated January 8, 1968.

(g) Lunar Module to Multiple Docking Adapter Instrumentation and Communications Interface, 50M13124, draft, dated January 8, 1968.

## 2.0 Saturn/AAP Frequency Plan

Some general comments which apply to more than one of the AAP mission configuration radio frequency summary sheets forming the Saturn/AAP Frequency Plan are listed below.

(a) An X-band rendezvous radar transponder will be carried by the MDA/AM/OWS and will be active only during the period of CSM/LM/ATM rendezvous with the MDA/AM/OWS.

(b) The periods of activity of the VHF ranging transponder unit carried by the MDA/AM/OWS will only be during rendezvous of CSM with MDA/AM/OWS and during rendezvous of CSM/LM/ATM with the MDA/AM/OWS.

(c) The EDAS will not be used and reference to it should be deleted.

(d) Each of the VHF/FM transmitters of the AM may be modulated by data from a variety of different sources selectable by crew or ground command in order to provide operational flexibility in the event of transmitter failure (e.g., the 230.4 MHz FM transmitter may be modulated by waveforms other than the real-time PCM data stream). The extent of this flexibility has as yet not been defined.

(e) LM systems will not be activated during the launch phase because of thermal control problems. Under current plans in the Apollo Program, the LM will not be activated until the CSM has docked with the LM and the LM has been separated from the launch vehicle. A major impact on LM systems design would result if this mode of operation were changed for AAP missions in order to allow operation of the LM VHF communications system in its VHF ranging transponder mode during rendezvous of the CSM with the LM/ATM. Consequently, it is likely that a VHF ranging transponder will be installed in the S-IVB/IU for mission AAP-4 (and possibly for mission AAP-2) to facilitate rendezvous of the CSM with the LM/ATM.

In the radio frequency summary sheet for mission AAP-1 and AAP-2 (docked configuration), it should be noted that the CSM will not be equipped with either an X-band rendezvous radar or an X-band rendezvous radar transponder.

The SS/FM telemetry link from the IU(DS-1) operating at 259.7 MHz during mission AAP-4 must be made inactive at the termination of launch powered flight or its frequency

changed because it would otherwise interfere with the VHF ranging system of the CSM during rendezvous of the CSM with the LM/ATM.

In the radio frequency summary sheet for mission AAP-5, the 2272.5 MHz transmitter is an S-band transmitter.

## 3.0 LM-A/ATM/MSFN Instrumentation and Communications Performance and Interface Specification

The contents of any spacecraft/MSFN performance and interface (P&I) specification should contain all of the transmission and modulation characteristics of the spacecraft and MSFN communications systems as well as all of the link performance requirements necessary to permit the calculation of the communications performance margin of each of the communications links between the spacecraft and the MSFN. In general, the LM-A/ATM/MSFN P&I specification does not contain enough information to permit these calculations to be made.

The LM-A/ATM/MSFN P&I specification does not contain performance requirements for telemetry, command, or voice communications links between the LM-A/ATM and the MSFN. The Apollo Program Specification for the LM/MSFN and the CSM/MSFN communication links contains the following performance requirements:

(a) Voice - The required minimum normal mode word intelligibility shall be 90 per cent based on the "American Standard Method for Measurement of Monosyllabic Word Intelligibility Test Guide." The required minimum S-band backup mode word intelligibility shall be 70 per cent.

(b) Telemetry - The performance requirement for the telemetry link shall be less than one error in $10^6$ bits.

(c) Up-data - The requirement for the up-data link shall be that no more than one correct message; shall be rejected per 1000 messages and that the probability of accepting a false message shall be less than one in $10^9$ messages.

It is recommended that these requirements be included in the LM-A/ATM/MSFN P&I specification. It is also suggested that a minimum required signal-to-noise ratio at some point in the receiving system equipment of each communication link be specified.

The LM P&I specification for the Apollo Program should be included in the LM-A/ATM/MSFN P&I specification as a reference document. In addition, it is recommended that all entries in the LM-A/ATM/MSFN P&I specification describing the LM/MSFN communications interface be direct extractions from the LM/MSFN P&I specification. Of course, all reference to and characteristics of the LM S-band steerable and erectable antennas and RF angle track system should be deleted from any such extraction. Furthermore, new values of LM "omni-directional" antenna radiation coverage (not less than ____dB with respect to a RCP theoretical lossless isotropic radiator of ___ per cent) as a function of mission configuration (LM/ATM, CSM/LM/ATM, LM/ATM/MDA/AM/OWS, etc.) must be used. The value of -3 dB for the LM S-band omni-directional antenna radiation coverage listed in Table 1 and Table 4 appears much too optimistic to be applicable when the LM/ATM is docked to the MDA/AM/OWS. It is also recommended that all of the various modes of operation of the LM Unified S-Band system equipment which could be used during mission AAP-4 be included in LM-A/ATM/MSFN P&I specification complete with corresponding LM and MSFN equipment transmission characteristics.

The LM-A/ATM/MSFN P&I specification should be amended to include LM and MSFN equipment characteristics for a VHF voice communications link between the LM and MSFN. It should also be noted that LM and MSFN equipment transmission characteristics used for S-band voice communications were omitted from this document.

It is recommended that information on the X-band rendezvous radar and transponder and on the VHF ranging system be deleted from this document because these spacecraft systems do not interface with the MSFN, but rather interface with other spacecraft modules.

## 4.0 Module to Module Interface Control Documents

These module to module interface control documents are concerned exclusively with hardwire interfaces between the various spacecraft modules of missions AAP-1 through AAP-4. However, there also exist radio frequency interfaces between

the LM and CSM (VHF voice, telemetry and ranging communications), between the CSM and the MDA/AM/OWS (VHF ranging communications), between the LM and the MDA/AM/OWS (X-band rendezvous radar communications), and between an extravehicular crewman equipped with a portable life support system (PLSS) and the CSM and/or the LM (VHF voice and telemetry communications) which also must be specified to the same degree as suggested for inclusion in the LM-A/ATM/MSFN P&I specification (Section 3.0). In addition, there also exists a hardwire communications interface between the LM and the CSM and between the PLSS and the MDA/AM/OWS which must be documented.

General comments on the specific module to module hardwire interface control documents reviewed are contained in the following paragraphs.

4.1 Apollo Telescope Mount to Lunar Module Instrumentation and Communication Interface

The following electromagnetic interference control and electromagnetic compatibility specifications should be included in Section 5.1.1, (Elcctromagnetic Interference Control), of this interface control document.

(a) Lunar Module MIL-I-26600 with addendum MSC-EMI-10A and MIL-E-6051.

(b) Apollo Telescope Mount MIL-I-6181D and MIL-E-6051C.

A single point negative grounding system for the combined LM and ATM appears to be specified in this interface control document, but the manner in which this specification will be implemented has been omitted. This design implementation information is required to define the interface between the instrumentation and telemetry system of the LM and the instrumentation and telemetry system of the ATM and should be included in this document.

4.2 Multiple Docking Adapter to Airlock Module Instrumentation and Communication Interface

Precise knowledge of where experiment S069 (X-ray Astronomy) is pointing is required to interpret the data gathered by the experiment. Consequently, space vehicle attitude and timing data is required as inputs to experiment S069 in order to enable correlation of X-ray count data with celestial location of X-ray sources. The data management system of this experiment has the capability to incorporate these data into its output if the data is supplied to the experiment. Since these data are

not available from MDA systems, these data must be supplied through the CSM/MDA hardwire interface or the AM/MDA hardwire interface and should, therefore, be described in the appropriate interface control document.

The comments contained in Section 4.1 concerning single point grounding system also apply to this document.

4.3 Orbital Workshop to Airlock Module Instrumentation and Communication Interface

The comments contained in Section 4.1 concerning single point grounding system also apply to this document.

4.4 Lunar Module to Multiple Docking Adapter Instrumentation and Communication Interface

An additional paragraph is required to describe the caution and warning system portion of the LM/MDA hardwire interface. The caution and warning system design of the CSM, LM/ATM, and MDA/AM/OWS is such that when a fault occurs in one of these, a discrete closure is provided to the other two for activating an alarm and a fault advisory panel light located in each. This caution and warning system discrete closure capability may also be used for transferring wake-up or call signals to a module by activating the alarm systems of the various modules and may be initiated from any module.

4.5 Command Service Module to Multiple Docking Adapter Instrumentation and Communication Interface

The comments contained in Section 4.2 and 4.4 also apply to this interface control document.

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